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Managing Water in the West

The Colorado River System: Projected Future Conditions 2016-2020

August 2015

U.S. Department of the Interior
Bureau of Reclamation

Background

- Future Colorado River system conditions were simulated using the Colorado River Simulation System (CRSS).
  - Comprehensive model of the Colorado River Basin
  - Primary long-term planning tool for studying river operations and projected development
- CRSS is implemented in the commercial river modeling software called RiverWare™ developed by the University of Colorado.
- CRSS is updated and maintained continually by Reclamation's Upper and Lower Colorado Regions.
- CRSS projections are updated at least two times annually (January and August).
- Due to uncertainties associated with future inflows into the system, multiple simulations are performed in order to quantify the uncertainties in future conditions, and the results are expressed in probabilistic terms, e.g. "percent of futures".

Key August 2015 CRSS Modeling Assumptions

- Simulations begin in January 2016.
- Initial reservoir conditions are based on the most probable August 2015 24-Month Study's projections of December 31, 2015 elevations.
  - Lake Powell: 3,602.46 feet
  - Lake Mead: 1,082.33 feet
- Future hydrology is developed by resampling the observed record of natural flows[1] (1906-2012), *see Figure 1*, to create 107 future hydrologic sequences using a resampling technique known as the Indexed Sequential Method.
- Lake Powell and Lake Mead operations are consistent with the 2007 Record of Decision on Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations of Lake Powell and Lake Mead (2007 Interim Guidelines), *see Figure 2.*
- Upper and Lower Basin water demands have been developed in coordination with the seven Colorado River Basin States.

[1]Natural flow represents flow that would have occurred at a location had depletions and reservoir regulation not been present upstream of that location.

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Figure 1
Natural Flow
Colorado River at Lees Ferry Gaging Station, Arizona

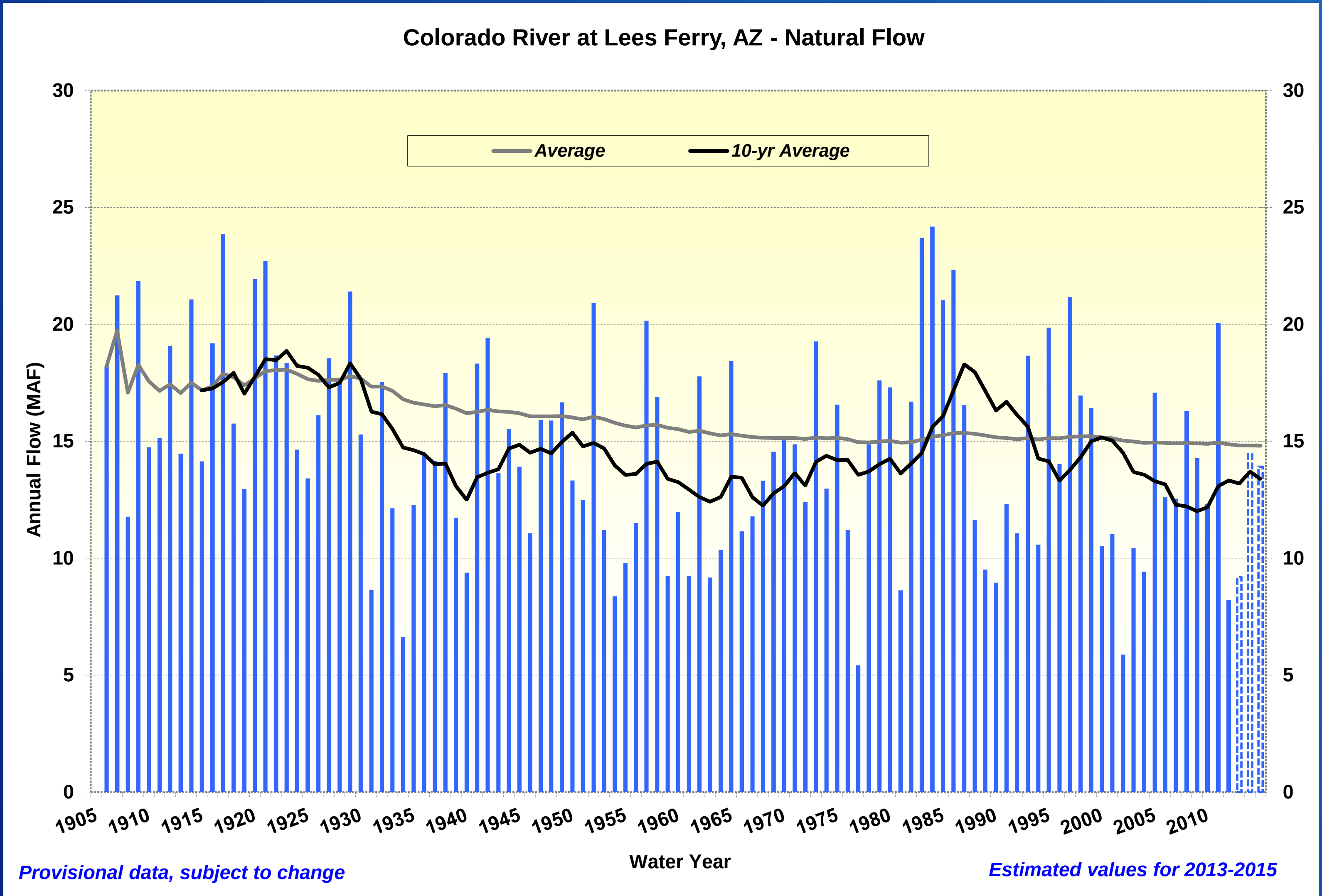

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Figure 2
Lake Powell & Lake Mead Operational Diagrams from the 2007 Interim Guidelines

Lake Powell

Elevation (feet)	Operation According to the Interim Guidelines	Live Storage (maf)[1]
3,700	**Equalization Tier** Equalize, avoid spills or release 8.23 maf	24.3
3,636 - 3,666 (2008-2026)	**Upper Elevation Balancing Tier**[3] Release 8.23 maf; if Lake Mead < 1,075 feet, balance contents with a min/max release of 7.0 and 9.0 maf	15.5 - 19.3 (2008-2026)
3,575	**Mid-Elevation Release Tier** Release 7.48 maf; if Lake Mead < 1,025 feet, release 8.23 maf	9.5
3,525	**Lower Elevation Balancing Tier** Balance contents with a min/max release of 7.0 and 9.5 maf	5.9
3,490		4.0
3,370		0

Lake Mead

Elevation (feet)	Operation According to the Interim Guidelines	Live Storage (maf)[1]
1,220	**Flood Control Surplus or Quantified Surplus Condition** Deliver > 7.5 maf	25.9
1,200 (approx.)[2]	**Domestic Surplus or ICS Surplus Condition** Deliver > 7.5 maf	22.9 (approx.)[2]
1,145	**Normal or ICS Surplus Condition** Deliver ≥ 7.5 maf	15.9
1,105		11.9
1,075	**Shortage Condition** Deliver 7.167[4] maf	9.4
1,050	**Shortage Condition** Deliver 7.083[5] maf	7.5
1,025	**Shortage Condition** Deliver 7.0[6] maf Further measures may be undertaken[7]	5.8
1,000		4.3
895		0

Diagram not to scale

[1] Acronym for million acre-feet

[2] This elevation is shown as approximate as it is determined each year by considering several factors including Lake Powell and Lake Mead storage, projected Upper Basin and Lower Basin demands, and an assumed inflow.

[3] Subject to April adjustments which may result in a release according to the Equalization Tier

[4] Of which 2.48 maf is apportioned to Arizona, 4.4 maf to California, and 0.287 maf to Nevada

[5] Of which 2.40 maf is apportioned to Arizona, 4.4 maf to California, and 0.283 maf to Nevada

[6] Of which 2.32 maf is apportioned to Arizona, 4.4 maf to California, and 0.280 maf to Nevada

[7] Whenever Lake Mead is below elevation 1,025 feet, the Secretary shall consider whether hydrologic conditions together with anticipated deliveries to the Lower Division States and Mexico is likely to cause the elevation at Lake Mead to fall below 1,000 feet. Such consideration, in consultation with the Basin States, may result in the undertaking of further measures, consistent with applicable Federal law.

Percent of Futures with Event or System Condition

Results from August 2015 CRSS[1,2,3] (values in percent)

	Event or System Condition	2016	2017	2018	2019	2020
Upper Basin – Lake Powell	**Equalization Tier**	**8**	**24**	**23**	**27**	**29**
	Equalization – annual release > 8.23 maf	8	23	23	27	28
	Equalization – annual release = 8.23 maf	0	0	0	0	1
	Upper Elevation Balancing Tier	**92**	**52**	**55**	**54**	**47**
	Upper Elevation Balancing – annual release > 8.23 maf	82	39	43	42	36
	Upper Elevation Balancing – annual release = 8.23 maf	10	13	11	10	11
	Upper Elevation Balancing – annual release < 8.23 maf	0	0	1	2	0
	Mid-Elevation Release Tier	**0**	**24**	**19**	**10**	**17**
	Mid-Elevation Release – annual release = 8.23 maf	0	0	0	1	1
	Mid-Elevation Release – annual release = 7.48 maf	0	24	19	9	16
	Lower Elevation Balancing Tier	**0**	**0**	**3**	**9**	**7**
Lower Basin – Lake Mead	**Shortage Condition – any amount (Mead ≤ 1,075 ft)**	**0**	**18**	**52**	**65**	**59**
	Shortage – 1st level (Mead ≤ 1,075 and ≥ 1,050)	0	18	42	47	35
	Shortage – 2nd level (Mead < 1,050 and ≥ 1,025)	0	0	10	14	18
	Shortage – 3rd level (Mead < 1,025)	0	0	0	4	7
	Surplus Condition – any amount (Mead ≥ 1,145 ft)	**0**	**0**	**6**	**7**	**15**
	Surplus – Flood Control	0	0	0	2	2
	Normal or ICS Surplus Condition	**100**	**82**	**42**	**28**	**26**

[1] Reservoir initial conditions based on December 31, 2015 conditions projected using the most probable August 2015 24-Month Study.
[2] Results are based on 107 hydrologic inflow sequences developed by resampling the observed natural flow record from 1906-2012.
[3] Percentages shown may not be representative of the full range of future possibilities that could occur with different modeling assumptions.

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References

- RiverWare
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- Indexed Sequential Method
  - Ouarda, T., Labadie, J.W., Fontane, D.G. (1997). "Indexed Sequential Hydrologic Modeling for Hydropower Capacity Estimation." *Journal of the American Water Resources Association,* 33(6), 1337-1349.
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  - http://www.usbr.gov/lc/region/g4000/NaturalFlow/index.html
- August 2015 24-Month Study
  - http://www.usbr.gov/uc/water/crsp/studies/24Month_08.pdf
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- 2007 Interim Guidelines
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